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Environmental Sustainability of Logistics Service Providers: A Systematic Literature Review on Indicators for City Logistics

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1. INTRODUCTION

The digital era has a definite emphasis on ‘timeliness’ for the modern supply chain. Both the volume and the distance of cargo travelling around the world has grown exponentially. Cities and urban areas with large populations and extensive commercial establishments have served as significant nodes for trade, merchandising, wholesale and retail distribution activities (Hesse, 2016, p.13). The high demand of just-in-time deliveries and asymmetrical patterns of trade has led to increasing demand for urban freight transport services - trucks on the road are running below capacity or running empty (Goldman and Gorham, 2006).

Inevitably, the level of carbon dioxide (CO₂) has risen significantly over the years. McKinnon (2018) pointed out that logistics activities generates about 9-10% of global CO₂ emissions and it is considered as the most difficult sectors to decarbonise. Road-intensive logistics activities in the city has posed a series of social, environmental and economic impacts in the urban areas, such as traffic congestion, greenhouse gas emissions, air pollution, noise pollution, and the consequences of traffic accidents (Browne *et al.*, 2012).

Logistics service providers (LSPs) has played a pivotal role in long-distance global shipping and last-mile city deliveries. In the past, improving environmental sustainability has been treated as an extra cost for the logistics service providers (LSPs), due to the low profit margins in the freight transport industry (Piecyk and Björklund, 2015). Under the sustainable development request, new requirements will be addressed to logistics service providers – ‘environmental sustainability’ is now becoming a supplier selection criterion (Wolf and Seuring, 2010; Björklund and Forslund, 2013) and a competitive edge for LSPs (Piecyk and Björklund, 2015) and even an expected dimension of modern logistics service offering (Evangelista *et al.*, 2018). However, because there are multiple organisations involved in the supply chain, it is very difficult for LSPs to gain visibility and measure their environmental sustainability as a focal organization (Piecyk *et al.*, 2015).

Over the past decades, the concept of sustainability has been embodied into government, industries and corporations' policies through ‘standards, conformity assessment, and metrology’ (Brand *et al.*, 2016). A variety of governmental initiatives, trails and pilot projects have been carried out to improve the sustainability of city logistics (Browne *et al.*, 2012). Sustainable city logistics can reduce logistics cost, improve transport efficiency and economic vitality, and ultimately, lead to a harmonious and sustainable development of the economy, the environment and society (Carlucci *et al.*, 2018).

From an academic perspective, Evangelista *et al.* (2018) conducted a systematic literature review on the environmental sustainability of third-party logistics service providers. Their study highlighted that the current research on LSP’s environmental performance measurement is

absent and inadequate. In addition, Tundys and Wiśniewski (2018) also carried out an extensive literature review on green and sustainable supply chain measurement methods. Their research study suggests that the various existing measurement instruments, tools, and methods may mislead and lack comparability for different entities, and that clearly defined KPIs (Key Performance Indicators) are needed to assess sustainable performance in logistics.

From an industry perspective, few global sustainability indexes are identified, such as the Global Reporting Initiative (GRI), the Green City Index developed by Siemens, the Climate Change Performance Index (CCPI) by GermanWatch, Dow Jones sustainability index (DJSI); FTSE4Good Index; MSCI Environmental, social and governance (ESG) Index. Some of these indexes focus on the city or country's environmental sustainability as a whole, while some are designed for the corporate social responsibility (CSR) reporting purpose of large and listed companies. Buldeo Rai. *et al.*(2018)'s study highlighted that freight transport and logistics related activities are underrepresented in these established frameworks and there is no current available globally agreed set of city logistics-related indicators to measure the environmental sustainability performance of LSPs' operations. Among the above-mentioned frameworks, the GRI framework was developed for organizations to report their sustainability performance from economic, environmental, and social aspects (Piecyk and Björklund, 2015) and a supplement set of indicators was developed in 2006 for the logistics and transport sectors. The Global Reporting Initiative (GRI) (www.globalreporting.org) framework was not included in Buldeo Rai *et al.* (2018)'s research.

To address this gap, this paper carried out a systematic literature review to answer two research questions:

RQ1: What environmental sustainability measurement frameworks and indicators are currently used by different industries for their logistics operations?

RQ2: Which of those indicators are the most appropriate to measure the environmental sustainability of city logistics?

This study fills the gap of current studies in logistics sustainability by providing a comprehensive review of the practical indicators dedicated for city logistics, to assess the environmental sustainability of logistics service providers (LSPs). The findings of this paper discovered important variables and indicators related to measure environmental sustainability in logistics activities. On this basis, an indicator framework was proposed to relate new findings to previous research.

The remainder of this paper is organised as follows: Section 2 presents the methodology employed to answer the research questions of this study and a brief descriptive analysis of the selected literatures. Section 3 presents the existing measurement frameworks and their applications through content analysis. Section 4 proposes a conceptual framework with a shortlist of practical indicators dedicatedly to measure city logistics environmental sustainability. At last, Section 5 discusses the implications of this study and future research agendas.

2. METHODOLOGY

Different from the literature review in traditional sense, the systematic literature review (SLR) is a 'self-contained' research project (Denyer and Tranfield, 2009). A SLR provides a rigorous and transparent 'evidence-informed approach', which helps researchers to explore a specific research query by capturing existing studies across disciplines, analysing and synthesizing literatures, and evaluating research findings (Denyer and Tranfield, 2009; Tranfield, Denyer, and Smart, 2003).

This study attempts to address the pressing need to make clear sense of the existing literatures surrounding the topic of logistics sustainability measurement and have a collective overview of what measurement frameworks and indicators of environmental sustainability have been discussed and used in academic research. Thus, a systematic literature review has been conducted in this study in order to map out and assess the relevant literatures to answer the two abovementioned research questions, and further develop the knowledge base and inform future research agendas.

2.1 Selection of literatures

Cooper (1984) and Denyer & Tranfield (2009) suggested that a SLR comprises the process of research question formation, selection of data (i.e. literatures), data evaluation, data analysis and report of the research findings. In this study, following this theoretical logic, the systematic review approach in also incorporate the processes from two recent SLR studies on the logistics sustainability topic - Evangelista *et al.* (2018) and Centobelli *et al.*(2017), the main steps were illustrated in Figure 1 below.

Firstly, research planning aimed to determine the research scopes and define keyword search strings. The academic database Scopus was primarily used as it includes extensive peer-reviewed international journals in science, technology, and management among others, and it is also used by many other published systematic literature review studies (Evangelista *et al.*,2018, Centobelli *et al.*, 2017) in the topic of third-party logistics sustainability.

Secondly, with an aim to align the literature search tightly with the research questions (Denyer & Tranfield, 2009), the keywords search was conducted using the keywords indicating environmental sustainability measurement and logistics service. The searched keywords string embedded with Boolean logic (Denyer & Tranfield, 2009) included *logistics, sustainability (or sustainable), environment (or environmental), measurement, indicator*. The articles that have matching phases in the article title, abstract, or author-supplied keywords were identified. We included peer-reviewed journal articles written in English language only.

The initial search resulted in 117 articles (status on 09 Jan 2019). Thereafter, the articles identified by the search were screened by reading the abstracts to exclude the unrelated articles that do not concentrate on the ‘logistics sustainability’ issues. This reduced the sample of literatures to 41 articles. A full text analysis was then carried out and an additional of 15 highly relevant cross-reference articles (including 5 conference proceedings) were found and included in the final sample. The final sample included 56 articles with relevance to the measurement of logistics environmental sustainability.

Thirdly, descriptive analysis was conducted to present the research trends throughout the recent years and across various academic fields. Content analysis were also carried out to capture the research trends, and identify key frameworks and indicators used in logistics environmental sustainability measurement to further develop the measurement index for city logistics.

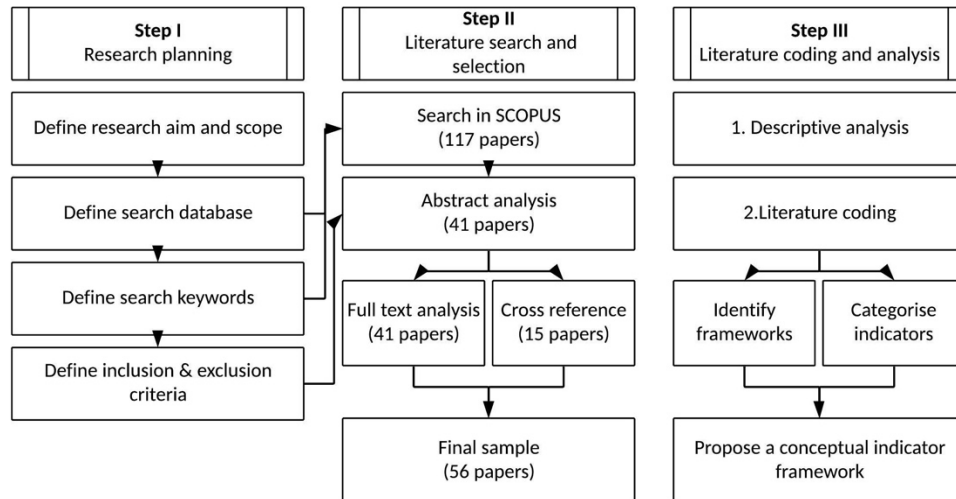


Figure 1: Research Method

2.2 Descriptive analysis of literatures

The total 56 articles were reviewed and outlined from the publishing time and sustainability assessment frameworks used. We also extracted and coded the environmental sustainability measurement indicators identified from the literatures.

Figure 2 below shows the number of the related articles from the year 2010 to 2019. In the initial search, we did not limit the time range. We can easily observe that increasing number of research goes to the measurement of logistics environmental sustainability issues in the recent decade. Evangelista *et al.*, (2018) observed that the formal implementation of the Kyoto Protocol in 2015 has a great influence on the increasing research interest on the issues of environmental sustainability in logistics operation. In our observation, the amount of research has enjoyed a rapid growth after 2015 as well. The year 2015 also marked a milestone in global sustainability development - the 2015 United Nations Climate Change Conference (known as COP 21 or CMP 11) was held in Paris, and in the same year United Nations also set the 17 Sustainable Development Goals (SDGs) to tackle human well-being, clean energy, environmental issue etc. These governmental initiatives may have to some degree stimulated the related research interests in freight transport sustainability and especially, how to measure the sustainable performance.

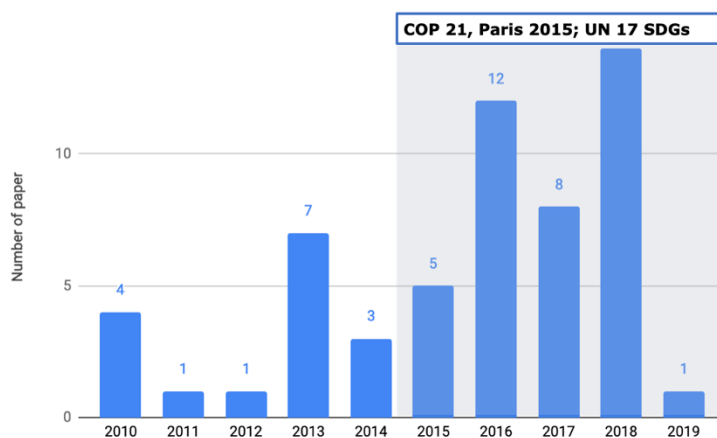


Figure 2: Number of Related Articles (2010-2019)

Note: COP21 is short for the 2015 United Nations Climate Change Conference; SDGs is short for Sustainable Development Goals.

The selected 56 papers have been published in total 35 international journals and conference proceedings. The journal coverage ranges from transportation research to energy, environment, urbanism, and benchmarking studies. A total of 17 (about one-third) out of 56 papers were identified in transportation and logistics-related journals and proceedings. This generally supports that the research of freight transport sustainability has grown as a cross-discipline area of transportation, energy and environment.

3. CONTENT ANALYSIS – MEASUREMENT FRAMEWORKS FOR LOGISTICS ENVIRONMENTAL SUSTAINABILITY

3.1 Logistics environmental sustainability measurement frameworks

Identifying the existing measurement frameworks and metrics for logistics environmental sustainability serves as a theoretical basis for this research to further develop a set of indicators to measure city logistics environmental sustainability. To achieve this goal, we categorized and analysed the sustainability measurement frameworks identified in the literature.

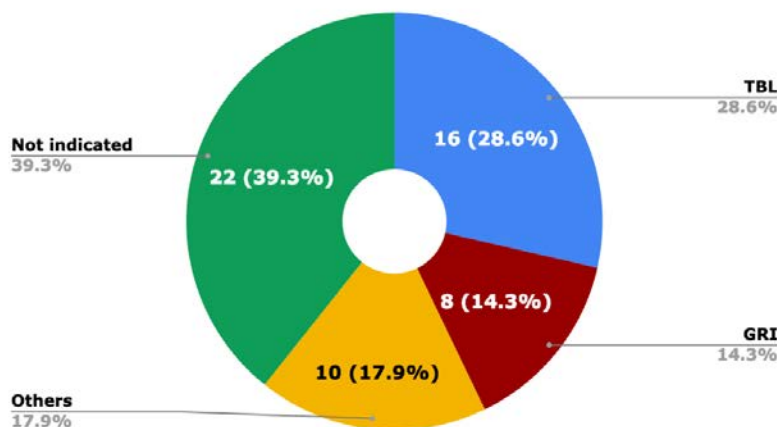


Figure 3: TBL and GRI Frameworks Usage Identified in the Literature

Note: TBL is short for Triple Bottom Line; GRI is short for Global Reporting Initiative

The overall usage of measurement frameworks (shown in Figure 3) indicated that 60.8% of the papers have applied or adopted measurement frameworks to measure logistics sustainability. Among them, the Triple Bottom Line (TBL) and the Global Reporting Initiative (GRI) are the two major frameworks adopted by scholars, about 42.9% of the papers are measuring sustainability from the triple bottom line approach - economic, environmental and social aspects.

The Triple Bottom Line (TBL) Framework

The triple bottom line (TBL) concept, was developed by Elkington (1998;2004, cited in Carter and Rogers, 2008). TBL is a fundamental framework, which provides three pillars to assess sustainability performance, namely economy (profit), environment (planet), and social (people), and is frequently used in sustainability research (Buldeo Rai *et al.*, 2018).

In our literature review, it is noted that scholars sometimes refined the TBL framework to fit their research context. For instance, Carter and Rogers (2008) expanded the conceptualization of sustainability by adding supporting indicators (i.e. risk management, transparency, strategy and culture) beyond the triple bottom line to assess sustainable supply chain practices. Policy, as an additional dimension of sustainability, also has been added in the study by Buldeo Rai *et al.*, (2018) with the aim to use urban transport (including both passenger and freight) sustainability indicators to support policy making.

The Global Reporting Initiative (GRI) Framework

The Global Reporting Initiative (GRI) framework was firstly launched in 1997 as a joint initiative of the U.S. non-governmental organization - Coalition for Environmentally Responsible Economies (CERES), and the United Nations Environment Programme with the goal to enhance sustainability reporting (Gallego-Álvarez and Vicente-Villardón, 2012). The GRI framework is deeply grounded within the triple bottom line (TBL) principle with economic, environmental and social pillars (Madiati *et al.*, 2018), and it is internationally recognised and considered as the most comprehensive sustainability evaluation framework for an organization to report their economic, environmental, and social performance (Piecyk and Björklund, 2015). The GRI can be considered as an advanced or detailed version of the TBL framework.

In 2006, the GRI has proposed a number of supplement indicators dedicated for the logistics and transport sector to make reporting more relevant and tailored to the sector's specific needs (Piecyk and Björklund, 2015). Beside economic and social indicators, nine categories of environmental indicators - energy, urban air pollution, fleet compositions, noise/vibration, congestion, policy and transport infrastructure development are proposed in GRI Logistics and Transportation Sector Supplement Pilot Version 1.0 (2006).

Other frameworks

Ten studies (17.9% of the sample of this research) use other theories and frameworks to investigate their specific research context. For example Lirn *et al.* (2019) apply institutional and stakeholder theory to identify green assessment criteria for shipping operators in Taiwan; Lam and Dai (2015) use analytical network process (ANP) with quality function deployment (QFD) techniques to evaluate the environmental sustainability of LSPs; Nathanail *et al.* (2017) adopt life cycle analysis for city logistics and proposed a supply/demand logistics sustainability index based on city logistics context.

No frameworks indicated/applied

Among the total 56 sample papers, 22 papers (39.3%) did not indicate the use of any established framework. These studies are only partially related to the measurement of logistics sustainability. They address a wide spectrum of research topics related to logistics environmental sustainability, ranging from port city sustainability (Nathanail *et al.*, 2016; Carlucci *et al.*, 2018), the role of environmental sustainability in LSPs operations (Björklund and Forslund, 2013; Bask *et al.*, 2016), and the systematic literature reviews on logistics environmental sustainability in LSPs (Centobelli *et al.*, 2017; Evangelista *et al.*, 2018).

However, these studies are equally important, because they not only helped us to map out the current research gaps in this area, but also supported our research to develop a well-round set of indicators to capture the environmental sustainability performance of LSPs in city logistics context.

3.2 Framework usage by industry

As the Triple Bottom Line (TBL) and the Global Reporting Initiative (GRI) are identified in 34 papers (i.e. 24 papers using only TBL or GRI, and 10 papers which are using other frameworks in addition to TBL and/or GRI), we further investigate these literatures to identify the research context that those measurement frameworks are applied. The aim of this step is to identify and validate the current research gap, and also to identify key literatures in our research area – city logistics/urban transport to extract environmental indicators.

In the content analysis, we coded and ranked the total of 56 papers by the number of papers that are focused in each industry sectors. Table 2 presents the distribution of major frameworks among the 34 papers which applied established frameworks. It is noted that we only listed the top 7 sectors based on the number of papers identified.

Table 2: Major Frameworks Identified in Different Industries

Industry	No.	TBL	GRI	Other Frameworks
City logistics	14	(Buldeo Rai et al., 2018) (Cheba and Saniuk, 2016) (Morana and Gonzalez-Feliu, 2015) (Garcia et al., 2015) (Tadić et al., 2018)	Research Gap	(Chen et al., 2010) (Giret et al., 2018) (Nathanail et al., 2017)
Freight transport	12	(Havenga and Simpson, 2018) (He et al., 2017) (Furtado and Frayret, 2015)	Research Gap	(Kim and Han, 2011) (Lai et al., 2013) (Kumar and Anbanandam, 2019) (Lirn et al., 2019)
Logistics service providers (LSPs)	7	(Klump, 2017)	(Piecyk and Björklund, 2015)	(Lam and Dai, 2015)
Energy	5	(Ngan et al., 2018) (Manara and Zabaniotou, 2014)		(Brandi et al., 2016) (Dos Santos and Brandi, 2016)
Reverse logistics	4	(Govindan et al., 2016) (Dhib et al., 2013) (Sarkis et al., 2010)	(Nikolaou et al., 2013)	
Retail logistics	4	(Papoutsis et al., 2018) (Matopoulos and Bourlakis, 2010)	(Andersson and Forslund, 2018) (Björklund et al., 2016)	
Manufacturing	4		(Ferreira et al., 2016) (Xu et al., 2016)	

*Note: *TBL is short for Triple Bottom Line; GRI is short for Global Reporting Initiative ** Not all 56 papers listed in the table, full list can be provided upon request.*

City logistics and urban transport rank the highest with 14 papers focused in this area; following by the freight transport sector with 12 papers, in which the research focus covers different transport modes; 7 papers purely focused on the LSP's side, therefore we separated these papers from those which are focused on freight transport.

By categorising the frameworks by sectors, we validated the research gap in city logistics environmental sustainability performance measurement. The analysis clearly shows that city logistics environmental performance measurement is underrepresented in these established frameworks, and that there is a lack of industry-standardised measurement framework for logistics service providers to track their own sustainable performance (Piecyk and Björklund, 2015). In addition, the GRI framework tends to be perceived and adopted widely by LSPs in retail, manufacturing, and reverse logistics sectors, which might be due to the higher customer's demand for sustainability reporting and corporate social responsibility. However, the research in city logistics has yet to adopt the GRI framework.

4. DEVELOPING INDICATORS FOR CITY LOGISTICS ENVIRONMENTAL SUSTAINABILITY

4.1 Indicator selection process

Inspired by Buldeo Rai *et al.* (2018)'s hierarchical design of an indicator framework, this study takes a stepwise approach to narrow down the scope and propose a set of practical indicators based the GRI frameworks. The GRI framework, aligning with the TBL framework, is well accepted in academia and is also coherent with indicator sets proposed by other organizations and institutions, such as OECD (Stindt, 2017).

In this study, firstly, we adopted the GRI Logistics and Transport Sector supplement framework which published in 2006 as a basis to build upon and finetune the indicator sets. Secondly, the systematic literature review has yielded more than 100 relevant indicators on environmental sustainability and assessment criteria for green transport. These indicators were extracted and coded into the GRI framework and its sub-categories. Thirdly, to further narrow down the indicator selection to city logistics context, four key articles (as shown in Figure 4 note) on city logistics environmental sustainability have been used to finetune the indicators.

4.2 Proposing a set of indicators for city logistics

With a focus on the environmental aspect, this research looked into the environmental sub-categories from GRI Logistics & Transport Sector supplement. We categorized the identified environmental indicators from the four key references with a dedicate focus on city logistics into the GRI sub-categories. The sub-category 'Material use' from the GRI framework has not been identified any related indicators in the four city logistics literatures, therefore we have excluded it in the proposed framework.

Using this GRI framework as the evaluation basis, a total of 15 new indicators dedicate for city logistics have been identified from literatures as shown in Figure 4. These new indicators for city logistics embedded with the GRI framework have provided a new update for the GRI logistics and transport sector guideline.

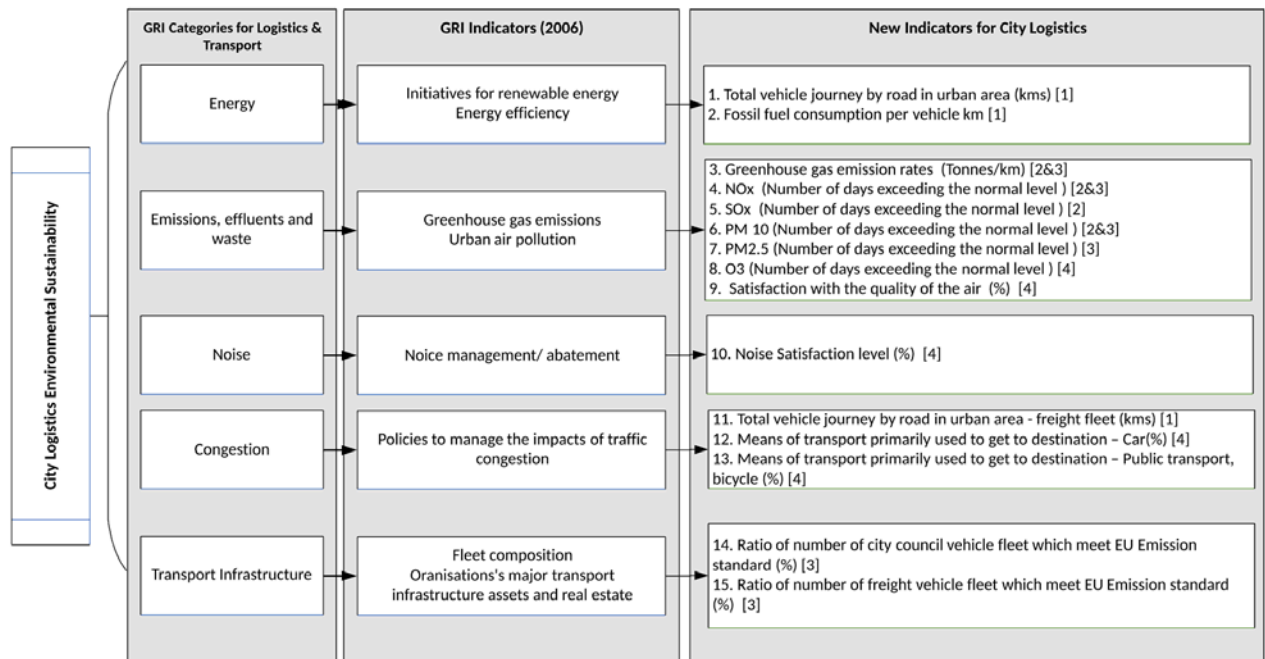


Figure 4: Environmental Sustainability Indicator Framework for City Logistics

Note: Reference list for the new indicators for city logistics are as follows: [1] Browne, M et al., 2012; [2] Morana and Gonzalez-Feliu, 2015; [3] Rai et al., 2018 [4] Cheba and Saniuk, 2016

5. CONCLUSION, IMPLICATIONS AND FUTURE RESEARCH AGENDA

This paper presented the content analysis of 56 papers on logistics environmental sustainability measurement. The existing two major frameworks – Triple Bottom Line (TBL) and Global Reporting Initiative (GRI) applications in logistics sector and the relevant indicators on city logistics environmental sustainability are reviewed. Moreover, linking various sustainable indicators with various city logistics practices, a conceptual framework and a shortlist of practical indicators dedicatedly to measure the city logistics environmental sustainability was proposed and provided a timely update to the GRI framework.

This paper provides a conceptual basis to develop a set of composite indicators for city logistics sustainability measurement. A robust set of indicators need to fulfil certain criteria, namely “dynamic, communicative, comprehensive, feasible, interpretable and relevant” (Buldeo Rai et al., 2018). Future research needs to validate and finetune the selected indicators. Thus, inspired by Huovila *et al.* (2019) ’s taxonomy research on smart cities, a comprehensive taxonomy of sustainability for city logistics can be developed to further evaluate all the selected indicators on the basis of “empirically observable” and “measurable characteristics” (Smith, 2002). Furthermore, the sets of indicators can be potentially aggregated into an index or dashboard to measure the logistics performance of the city, therefore to fulfil strategic and practical needs, such as to assist the industry to pinpoint the hurdles for LSPs and monitor their progress on decarbonising in freight transport operations, and support government in policy making for decarbonisation.

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(*Indicates the paper is included in the systematic review. Due to the page limit, full list of reference can be provided upon request.)

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